DATA EVALUATION RECORD

PC Code: 128931/100094 **Dicamba, DGA and BAPMA Salts**

Reference: Foster MR, Griffin JL (2018). Injury Criteria Associated with Soybean Exposure to Dicamba. Weed Technol. doi: 10.1017/wet.2018.42

Test material: Clarity (Reg No. 7969-137)

Common name: Dicamba

Study classification: Supplemental

Primary Reviewer: _____ 2018.10.30 13:23:37 -04'00'
Frank Farrugia, Ph.D. Date
EPA Reviewer

Secondary Reviewer: _____ 2018.10.30 15:26:52 -04'00'
Chuck Peck Date
EPA Reviewer

Secondary Reviewer: _____ 2018.10.30 13:42:27 -04'00'
Michael Lowit, Ph.D. Date
EPA Reviewer

Reviewer Conclusions

This field study evaluated the impact on non-dicamba resistant soybean (three cultivars: Pioneer 94Y80, Terral REV 51R53, and Asgrow 4835, one for each of the three years of the experiment) from direct spraying of dicamba (DGA, Clarity® herbicide). Soybean plants were treated at one of 10 rates of dicamba. A single treatment was made to plants at both the V3/V4 development stage and the R1/R2 stage. Separate experiments were conducted over three years. Plants were evaluated for severity of % injury and percent reduced height at 7 and 15 days after treatment (DAT), mature plant height prior to harvest, and grain yield (moisture adjusted) at harvest.

For the purposes of this review, the methods and results related to plant height and yield were evaluated. Equations provided in the manuscript allow for the estimation of a 5% effect on mature plant height and grain yield and were calculated during this review.

Reviewer estimated endpoints

5% Grain Yield Reduction
V3/V4 Exposure = 2.33 g ae/ha
R1/R2 Exposure = 1.24 g ae/ha

5% Mature Plant Height Reduction
V3/V4 Exposure = 2.02 g ae/ha
R1/R2 Exposure = 11.15 g ae/ha

Materials and Methods

Several experiments testing the effects of dicamba on soybeans were conducted over 3 years at the Louisiana State University (LSU) Ag Center, Central Research Station, Ben Hur Research Farm in Baton Rouge. The soil type and soil classification for the experiments was a Mhoon silt loam (fine-silty, mixed, nonacid, thermic Typic Fluvaquent) with a pH of 6.3 and organic matter content of 1.9%. Soybean cultivars were 'Pioneer 94Y80' (relative maturity 4.8) in 2013, 'Terral REV 51R53' (relative maturity 5.1) in 2014, and 'Asgrow 4835' (relative maturity 4.8) in 2015. Planting dates were June 6, 2013, May 21, 2014, and May 6, 2015, and seeding rate was 300,000 seed/ha. Pest control was achieved with S-metolachlor (at plant), glyphosate (at 5-8 cm weed height and 14 days later), as well as unnamed fungicides and insecticides.

The DGA salt formulation of dicamba (Clarity® herbicide; BASF Corp., Research Triangle Park, NC) was applied to soybean at V3/V4 (third/fourth node with two to three fully expanded trifoliates) or at R1/R2 (open flower at any node on main stem/open flower at one of the two uppermost nodes on main stem). Dicamba rates included 0.6, 1.1, 2.2, 4.4, 8.8, 17.5, 35, 70, 140, and 280 g ae/ha (1/1,000 to 1/2 of the manufacturer's use rate of 560 g/ha). Nonionic surfactant at 0.25% vol/vol was added to all treatments, and a nontreated control was included for comparison. A randomized complete block design with a factorial arrangement of treatments (growth stage by dicamba rate) and four replications were used each year.

For each experiment, dicamba treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha (15 gal/A) spray volume at 270 kPa (39 psi). Sprayers were fitted with 110-degree Turbo TeeJet Induction flat spray nozzles (TeeJet® Technologies, Spraying Systems Co., Wheaton, IL, specific nozzle variety not provided), and wind speed at application was no more than 4.8 kph (3 mph). Treated areas consisted of two rows spaced 76 cm apart with a nontreated border area between plots of 152 cm. Study authors considered the border area was sufficient to prevent cross-contamination between adjacent plots.

Application dates, temperature, rainfall, soil temperature, and relative humidity were tracked for 4 days post application. There was no irrigation provided.

Fourteen injury criteria associated with dicamba exposure were identified as upper canopy leaf cupping, terminal leaf cupping, upper canopy pale leaf margins, upper canopy leaf surface crinkling, upper canopy leaf rollover/inversion, lower leaf soil contact, leaf petiole droop, leaf petiole base swelling, terminal leaf chlorosis, terminal leaf necrosis, terminal leaf epinasty, stem epinasty, lower stem base swelling, and lower stem base lesions/cracking. Each criterion was visually rated 7 and 15 d after dicamba treatment (DAT) using a scale of 0 to 5, with 0=no injury, 1=slight, 2=slight to moderate, 3=moderate, 4=moderate to severe, and 5=severe. Injury ratings were determined from five plants selected at random within each row of the two-row plots. Plants were evaluated for each injury criterion using the 0 to 5 scale, and a value representative of the 10 plants was recorded. In addition, an overall visual assessment of soybean injury 7 and 15 DAT was made using a scale of 0 to 100%, with 0=none and 100%=plants dead. An attempt was made to include the level of injury observed for specific injury criteria in the overall injury assessment. Around 15 days is when injury expression is highly visible (Griffin et al. 2013; Egan et al. 2014), and over time plant symptoms can become less noticeable because

of plant recovery or death. Plant height reduction compared with the nontreated control was also determined 7 and 15 DAT using the 0 to 100% scale. Mature plant height was measured just prior to harvest from five randomly selected plants from each treated row. Soybean was combine-harvested on October 28, 2013, on October 16, 2014, and on October 5, 2015, and yields were adjusted to 13% moisture.

A statistical approach (described in paper) yielded two regression equations. Equation 1, representing percent visual injury and plant height reduction was a three-parameter sigmoidal equation.

$$y = a / (1 + exp(-(x + x_0) / b))$$

y= visual injury or plant height reduction
a = an asymptote,
x_0 = dicamba rate resulting in a given measure of y
b = slope of the curve around x_0
x= dicamba rate

Equation 2 represented the nonlinear exponential decay model for mature height and yield.

$$y = ae^{-bx}$$

y= plant yield or mature plant height
a = an asymptote,
e = Euler's number (constant)
b = slope of the curve around
x= dicamba rate

Results

Mature Plant Height

Soybean mature height in response to dicamba rate followed an exponential decay pattern for both application timings. Soybean mature height when dicamba was not applied was 78.6 cm for the V3/V4 treatments and 72.1 cm for the R1/R2 treatments (**Figure 3**). For individual rates of dicamba, mature plant height was negatively affected more when soybean was exposed at V3/V4 than at R1/R2. For exposure at V3/V4 to 0.6 g/ha dicamba, mature height was reduced 1% but was not reduced for the same rate applied at R1/R2. For exposure at V3/V4, mature plant height was reduced 5% at 2.2 g/ha, 20% at 8.8 g/ha, and 59% at 35 g/ha. In contrast, plant height for soybean exposed at R1/R2 was reduced 1% at 2.2 g/ha, 4% at 8.8 g/ha, and 15% at 35 g/ha.

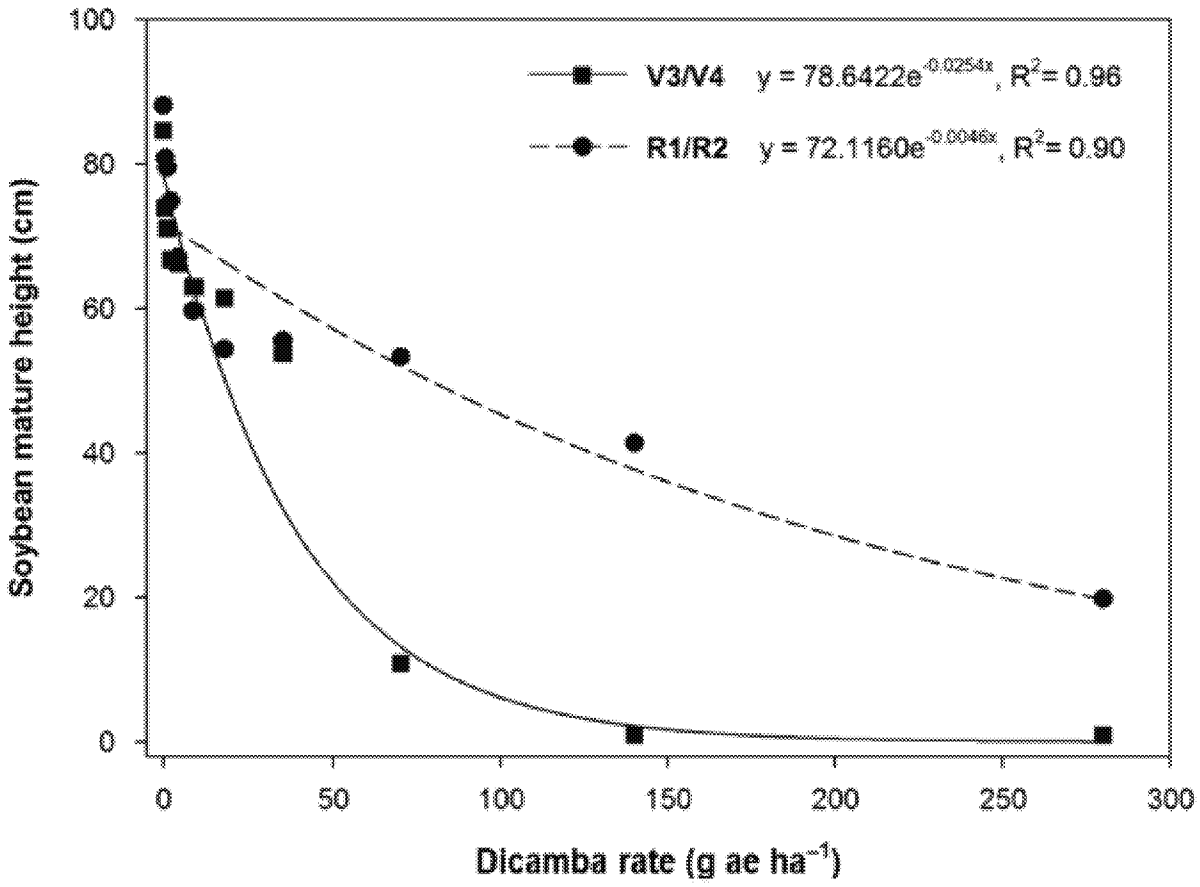

Figure 3. Soybean mature height as influenced by dicamba rate and application timing at V3/V4 and R1/R2.

Soybean Yield

Soybean yield in response to dicamba rate followed an exponential decay pattern for both V3/V4 and R1/R2 applications. When dicamba was not applied, soybean yield was 4,250 kg/ha for V3/V4 treatments and 4,014 kg/ha for R1/R2 treatments (**Figure 4**). For individual rates of dicamba, soybean yield was negatively affected more when soybean was exposed at R1/R2 than at V3/V4. Following exposure to dicamba at V3/V4, soybean yield was reduced 5% at 2.2 g/ha, 18% at 8.8 g/ha, and 54% at 35 g/ha. Yield for soybean exposed at R1/R2 was reduced 9% at 2.2 g/ha, 30% at 8.8 g/ha, and 76% at 35 g/ha, a reduction in yield around twice that compared with the same rates at V3/V4.

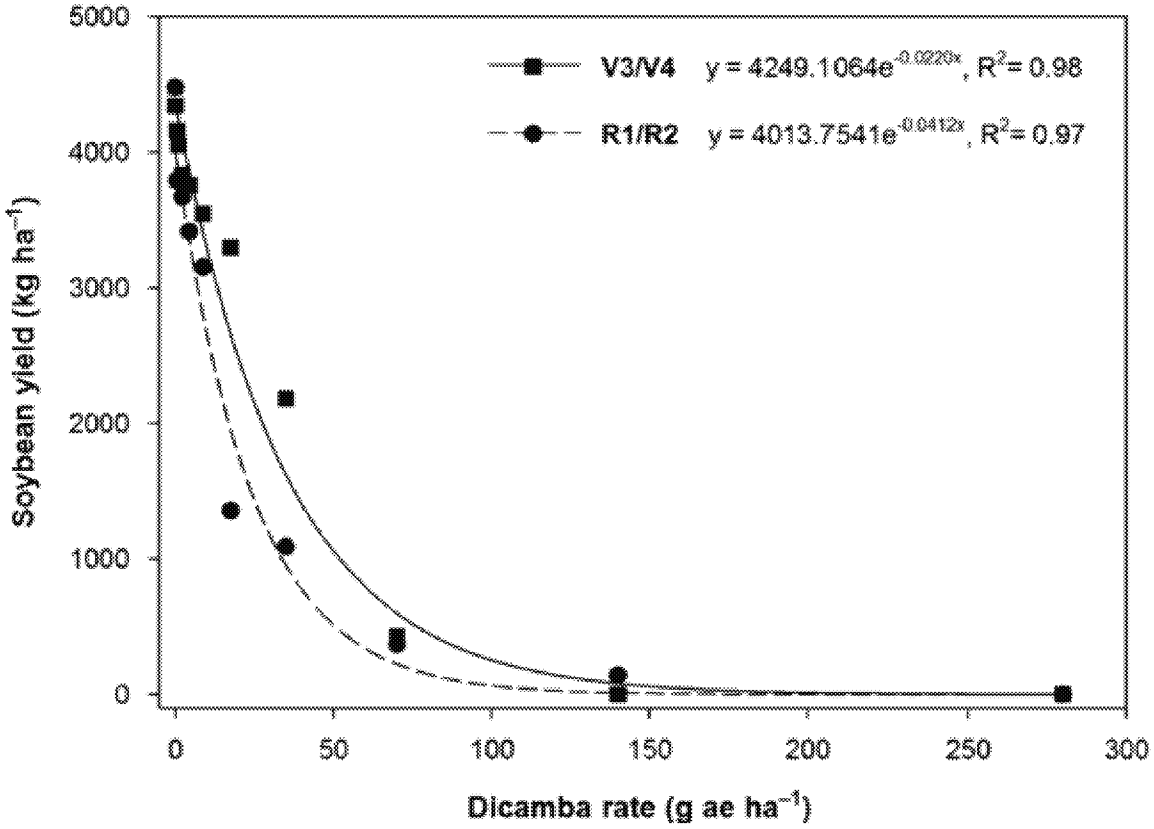

Figure 4. Soybean yield as influenced by dicamba rate and application timing at V3/V4 and R1/R2.

Additional results and discussion were provided for % injury and soybean % height reduction (e.g., Figures 1 & 2). Those results are not considered in this review because the number of days after treatments (7 and 15 days) were shorter than the duration that EFED is evaluating post exposure (e.g., 21-28+ days) which reflect the impact of delayed effects observed in many studies testing dicamba.

Deficiencies/Issues Related to Utility for EPA

- The prior history of the field site (i.e., pesticides applied) was not reported
- Several other pesticides (herbicides, insecticides, and fungicides) were applied during the experiment from the day of planting to past the R3 stage (although applications were made after R3, it was unspecified how many, which pesticides, or when).
- A randomized complete block design was used in the field; however, no details were provided about how cross-contamination was prevented among the plants in the different groups during the application phase (i.e., the controls, the 10 different treatment levels, and the timing of applications to different growth stages) other than indicating that a 152 cm non-treated area was maintained between plots and "*was sufficient to prevent cross-contamination between adjacent plots*". Furthermore, no details were provided on how cross-contamination was prevented after application given that dicamba is volatile.

- Experiments were conducted in 2013, 2014, and 2015 with a different soybean cultivar each year. The data from those experiments were combined for analysis. Presumably the full experimental design was repeated each year; however, it is unclear.
- It is unclear how well the nominal application rates consistently represent relative exposure to each plant given that a backpack spray was used to apply the test material and no direct measurement of the application rate was provided to confirm that the rate cited in the study was accurate.
- No indication as to how much water was used in the tank mix.
- Height measurements were on only five randomly selected plants per row (the reviewer interpretation of the methods is that there were two rows per treatment group per year for a total of only 10 plants per treatment group per year).
- It was not stated how many plants were harvested per treatment group for grain yield measurements. It is not clear if yield differences among treatment groups reflected grain yield normalized by plant number or if it also reflected any treatment group differences in the number of plants harvested.
- The analysis did not calculate NOAEC values or ICx values.
- Raw data were not requested from the authors for this review, as a result, while regressions are possible, the statistics generated are more reflective of the central tendency of the model and not measurement or response variability.